Somatotypological features of athletes specializing in acyclic sports

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Abstract

The *purpose* of the study was to identify similarities and differences in physique and body composition indicators among athletes specializing in acyclic sports, taking into account somatotype categories.

Methods: Physical fitness was assessed based on indicators of the cardiorespiratory system, which serve as integrative measures of physical performance:

1. VC, ml - vital capacity of the lungs was determined using a spirometer.
2. Breath-holding on inhalation, s – Stange's test.
3. Heart rate in 1 min - pulse was counted in beats/min using pulsometry.
4. Arterial pressure, max - systolic blood pressure (SBP) was determined in mmHg using a tonometer.
5. Arterial pressure, min - diastolic blood pressure (DBP) was determined in mmHg using a tonometer.

Discussion. A wide range of fluctuation in the standard deviation, from 2.06 to 9.93, within the same parameter was found only for abdominal circumference, which is associated with the greater variability of this feature across the entire sample of athletes studied. High standard deviation values are noted for thigh length and circumference, as well as for abdominal circumference. For instance, the abdominal circumference in boxers was 76.35±0.66 cm, whereas in fencers, the value was much lower at 70.75±0.88 cm.

Conclusion: An analysis of the musculoskeletal system revealed the presence of some postural disorders in the athletes. Specifically, some boxers showed signs of scoliosis and kyphosis, which indicates the need for regular monitoring of the spine and the use of preventative exercises for posture correction. A study of cardiorespiratory system indicators showed that the baseline functional capabilities of the cardiovascular and respiratory systems in qualified boxers are at a high level and correspond to physiological norms. Following physical exertion, a natural increase in heart rate and other indicators is observed; however, recovery occurs within a relatively short period. This indicates a high adaptive capacity of the body and a good level of fitness among the athletes. Thus, the research findings confirm that the training process in acyclic sports contributes to the development of mesomorphic body characteristics, the formation of a dominant ecto-mesomorphic somatotype, and an increase in the functional capabilities of the athletes' cardiorespiratory systems.

Keywords: somatotype, acyclic sports, boxing, fencing, body mass composition, anthropometric indicators, cardiorespiratory system, vital lung capacity, heart rate, physical performance, musculoskeletal system, physical fitness of athletes.

Introduction

In recent years, scientists have shown increased interest in studying the mechanisms by which various environmental factors affect the human body, leading to a complex of morpho-physiological responses. The changes that occur in the body as a result of exercise and sports are of particular interest. Modern sports involve loads that push the limits of human physiological and psychological capabilities. These conditions demand a scientifically-grounded approach to organizing the training process. This includes balancing intensive training with other activities and considering the athlete's individual morphological and functional characteristics - specifically, not only assessing the body's immediate individual response to a given load but also being able to predict and forecast it. In recent years, acyclic sports, particularly boxing and fencing, have undergone decisive changes in most aspects of athlete preparation. Using old methods, it is difficult, and sometimes impossible, to bring an athlete to peak competitive form in line with modern requirements. The search for new paths, programs, and methods continues to this day. In this regard, practitioners often miss the mark with timing, and theorists with their predictions.

When developing model characteristics for athlete selection, of particular interest - in addition to various physical development indicators - are data on body composition and the functional reserves of the cardiorespiratory system, the parameters of which serve as an indicator of athletic performance. A fundamental principle of athletic selection is the concept of a real-world population of individuals with exceptionally high levels of morphological and functional qualities, the significance of which is undeniable for achieving success in sports [3, 4, 11, 5, 9].

In this regard, the morphofunctional indicators and motor preparedness of fencers and boxers can be used not only to assess an athlete's level of training, but also to clearly plan the focus of the training process and to conduct athletic selection correctly and objectively.

Table 1. Total body measurements of athletes specializing in acyclic sports

Measurements	*Parameters*	*Boxing n=50*	*Fencing n=24*
Body length	M±SEM	173.61±0.77	177.14±1.61
	Variance	32.95	51.69
	Standard deviation	5.74	7.19
Body mass	M±SEM	64.13±0.91	65.64±2.00
	Variance	45.85	79.60
	Standard deviation	6.77	8.93
Chest circumference	M±SEM	93.55±0.93	90.60±0.97
	Variance	42.79	18.89
	Standard deviation	6.54	4.35

Current Understanding of the Problem: The question of how morphological components and physiological characteristics mutually influence the formation of a particular somatotype remains poorly understood. Outstanding athletic achievements are the result not only of rigorous training but also of an athlete's unique hereditary traits, as the prognostic significance of morphological features in the development of motor skills within the sports selection system has been proven. According to several authors, the development of most morphological traits is under significant hereditary or genetic control [5, 8, 6, 7, 11]. The prognostic value of these indicators is high and significant. Longitudinal measurements are more genetically determined in their development compared to circumferential anthropometric indicators. There is evidence that a number of the most important physiological indicators directly related to athletic achievement (energy capabilities, respiratory capacity, specifics of cardiovascular function, and especially maximum oxygen consumption) are largely, and in some cases 80-90%, genetically determined [1, 5, 8].

Based on the factual data presented above, it can be concluded that people are born with certain anatomical and physiological predispositions, and abilities are formed on the basis of these predispositions during the course of activity. Such morpho-physiological predispositions make it possible to predict the body's capacities, such as athletic performance and enhanced motor skills, and allow for the correct selection of training regimens.

The morphological section of the research includes the following methods:

1. The physical development of the athletes was assessed using anthropometric methods, specifically, indicators of total and partial body dimensions.

2. Constitutional types were determined using the Heath-Carter method, 1989 [12].

Using modern anthropometric methods with standard instruments (anthropometer, sliding caliper, spreading caliper, measuring tape, and skinfold caliper), we examined 24 qualified boxers and 24 fencers who had been regularly training in their chosen sport for 6-7 years. The study group of 48 individuals specialized in acyclic sports - boxing (24) and fencing (24) - in which performing sports exercises requires movements characterized by the following traits: asymmetry, precision, endurance, flexibility, and maintaining balance. The exercises are performed with a partner.

Longitudinal, transverse, and circumferential body dimensions, as well as skinfold thickness, were taken from the examined athletes.

Longitudinal dimensions:body length (height) and the length of the upper and lower limbs. The height above the floor of the following anthropometric points was determined: acromial, radial, styloid, anterior superior iliac spine, trochanteric, tibial, and malleolar. Based on these, the lengths of the upper arm, forearm, hand, thigh, and lower leg were calculated.

Transverse dimensions:biacromial (shoulder width), transverse chest, anteroposterior chest, and biiliocristal (pelvic) widths.

Circumferential dimensions: body weight,head, neck, and upper arm (flexed and relaxed) circumferences; chest circumference (at rest, during inhalation, and exhalation); and caliper measurements of skinfolds in 4 body regions: subscapular, suprailiac, on the posterior surface of the calf, and on the triceps.

Based on the results of anthropometric measurements, key anthropometric parameters were calculated, including the arithmetic mean, variance, standard deviation, and variation. It is necessary to emphasize the advantage and relia

Table 1. Segmental body measurements of athletes specializing in acyclic sports

Measurements Length	Parameters	Boxing n=50	Fencing n=24
Arm	M±SEM	33.20±0.28	33.10±0.56
		4.36	6.29
	Variance	2.09	2.51
	Standard deviation	0.06	0.08
Forearm	M±SEM	27.10±0.28	28.30±0.46
		4.19	4.21
	Variance	2.05	2.05
	Standard deviation	0.08	0.07
	Coefficient of variation		
Hand	M±SEM	20.45±0.15	20.70±0.30
		1.25	1.81
	Variance	1.12	1.35
	Standard deviation	0.05	0.06
Thigh	M±SEM	46.40±0.71	45.30±1.48
	Variance	27.94	44.01
	Standard deviation	5.29	6.63
	Coefficient of variation	0.11	0.15
Shank	M±SEM	41.45±0.55	44.30±0.88
	Variance	16.55	15.61
	Standard deviation	4.07	3.95
	Coefficient of variation	0.10	0.09
Head circumfer-ence	M±SEM	57.50±0.20	57.56±0.37
		2.25	2.69
	Variance	1.50	1.64
	Standard deviation	0.03	0.03
Neck circumfer-ence	M±SEM	37.05±0.26	36.00±0.52
		3.47	5.33
	Variance	1.86	2.31
	Standard deviation	0.05	0.06
Abdomen circum-ference	M±SEM	76.35±0.66	70.75±1.49
		24.93	93.69
	Variance	4.93	9.68
	Standard deviation	0.07	0.14
Arm circumfer-ence	M±SEM	30.55±0.45	29.83±0.75
		10.14	13.47
	Variance	3.18	3.67
	Standard deviation	0.10	0.12
Forearm circum-ference	M±SEM	26.90±0.25	26.11±0.49
	Variance	3.23	5.65
	Standard deviation	1.80	2.38
	Coefficient of variation	0.07	0.09
Thigh circumfer-ence	M±SEM	49.33±0.88	52.00±1.17
	Variance	38.41	32.89
	Standard deviation	6.20	5.73
	Coefficient of variation	0.13	0.11
Lower leg	S±m	35.26±0.83	35.54±0.45
	Variance	3.24	4.09
	Standard deviation	1.80	2.02
	Coefficient of variation	0.05	0.06
Shoulder width	S±m	42.67±0.49	41.56±0.72
	Variance	13.37	10.47
	Standard deviation	3.66	3.24
	Coefficient of variation	0.09	0.08
Mean transverse chest diameter	S±m	26.62±0.34	26.78±0.42
	Variance	6.24	5.51
	Standard deviation	2.50	1.87
	Coefficient of variation	0.09	0.09
Mean sagittal chest diameter	S±m	18.45±0.31	18.22±0.31
	Variance	5.45	1.95
	Standard deviation	2.33	1.40
	Coefficient of variation	0.13	0.08
Iliocristal (pelvic) diameter	S±m	28.81±0.33	25.89±0.54
	Variance	5.87	5.33
	Standard deviation	2.42	2.42
	Coefficient of variation	0.09	0.09

Table 3. Body composition of athletes specializing in acyclic sports (heath-carter method)

Specialization	No. of subjects	Component Score		
		Endomorphy	Mesomorphy	Ectomorphy
Fencing	23	2.5	4.4	3.7
Boxing	24	2.6	3.5	2.9
Fencing	23	2.5	4.8	3.9
Boxing	24	2.6	4.1	3.0

bility of a mathematical indicator such as the standard deviation. It is a better estimate compared to the range of variation, as its value does not depend on the sample size, and it is possible to determine this value quite accurately even when using a relatively small sample for calculations. Furthermore, when interpreting intra-group and inter-group indicators of diversity and variability, the standard deviation accounts for not only the range of variation but also the distribution of the arithmetic means of individual groups.

The somatotype was determined using the Heath-Carter method, 1989.

Initially, standard anthropometric measurements were taken for 7 dimensional characteristics: body length, weight, diameter of the distal humerus and femur, tensed arm circumference, and calf circumference. Additionally, a caliper was used to measure skinfolds in 4 regions of the body. The somatotype was diagnosed by the quantitative expression of three somatic components:

I - F - fat component - endomorphy

II - M - muscle component - mesomorphy

III - ectomorphy component. - L/P

endomorphic component was calculated using the formula:

F=Σ - sum of skinfolds on the posterior surface of the shoulder, subscapular, suprailiac, and on the calf.

Mesomorphic component:

M=Σ (sum of deviations) of the humerus and femur condyle diameters minus a constant

The ectomorphic component was determined by the formula: L3/P

The X coordinate is calculated as X = III-I components.

The Y coordinate is calculated as Y = 2 II - (III+I).

The sums of the component scores do not have arbitrary limits; in other words, the sums can be lower than 3 and higher than 12.

The final assessment of the somatotype is based on a combination of an anthroposcopic evaluation and the height-weight index [12]. In addition to hereditary influences, the formation of a somatotype is subject to the tremendous modifying force of training on the body's morphological features, which significantly alters the somatic type. In this regard, we conducted a re-evaluation of the somatotypes of 24 boxers at 1-year intervals. All calculations are presented in tables indicating the degree of expression of each component in points, as well as the X and Y values.

Table 4. Distribution of athletes specializing in acyclic sports

Parameters	Pre-exertion parameters (n=10 boxers)	Post-exertion parameters (n=10 boxers)
Chest circumference (cm)	90±3.5	95±3.4
VC, mL	4,400±1,200	4,200±1,200
Breath-hold time on inhalation, s	70.1 ±3.5	66.4±3.9
Heart rate (bpm)	69.4±1.3	85.1±3.1
Systolic blood pressure	120±1.2	120.5±3.8
Diastolic blood pressure	72.5±3.4	68.1 ± 2.1

4. Methods of mathematical statistics

The following formulas were used to calculate statistical indicators. Arithmetic mean, general formula for ungrouped data [10].

xi - variate ni - number of variates (i = 1,2,3...n)

$$X_avg = \frac{\Sigma xi}{ni}$$

$$Or\ X_avg = \frac{X1+X2+X3+...+Xn}{n}$$

$$\delta = \sqrt{\Sigma \frac{(x_i - \bar{x})^2}{n-1}}$$

δ = standard deviation, x - value of the variable in the sample, n - sample size. The lev-

el of significance of the differences was determined by the t-test.

Result and discussion

Table 1 presents data on the intragroup variability of total and partial body measurements of athletes specializing in acyclic sports, specifically boxers and fencers. The greatest body height is observed in fencers (177.14±7.19 cm), compared to boxers (173±5.74 cm). The arithmetic mean for body mass is 65.64±8.93 kg for fencers and 64.13±4.43 kg for boxers. An opposite trend is characteristic of the average chest circumference, which is 93.55±6.54 cm for boxers; for fencers, this indicator is lower at 90.67±4.35 cm. The values of the standard deviations range from 4.43 to 8.93. When assessing the total body measurements of the athletes, it should be noted that despite having a shorter body height and lower body weight, boxers exhibit a larger chest circumference. Among the partial measurements, significant differences are found between the representatives of the two specializations in thigh and lower leg length, neck, abdomen, shoulder, and thigh circumference, and pelvic width. For instance, the biiliocristal breadth for boxers is 28.81±0.3 cm**,** while for fencers, the pelvis is narrower at 25.89±0.54 cm. In a number of other anthropometric indicators, the samples of boxers and fencers were more similar. For example, in the indicators for the length of the shoulder, forearm, hand, head, and neck, as well as forearm circumference, and mid-thoracic transverse and sagittal diameters.

High standard deviations are observed for thigh circumference in boxers (49.33±0.83 cm); however, the values for fencers are higher at 52.00±1.28 cm. For the distal humerus diameter, high values were found for both boxers and fencers, at 6.98±0.16 cm and 6.93±0.24 cm, respectively.

Table 3 and Table 4 show the dynamics of changes in somatotypological indicators in boxers and fencers. Quantitatively, the somatotype categories were distributed as follows: among fencers, meso-ectomorphic somatotypes accounted for 21.5%, ecto-mesomorphic somatotypes for 71%, endo-mesomorphic for 8%, and the incidence of ecto-endomorphs was 4%. The distribution of somatotype categories among boxers was as follows: the dominant ecto-mesomorphic somatotype accounted for 62%; the meso-endomorphic somatotype represented 4.5%; the incidence of the endo-mesomorphic somatotype was 16.5%; and the meso-ectomorphic somatotype accounted for 12.5%. Whereas the average somatotype score at the initial baseline for boxers was 2.6: 3.5: 2.9, after a one-year interval, changes occurred in both the indicators characterizing the level of athletic skill and the associated changes in the athletes' morphological status. Under the influence of the training process, this can transition to either an endo-mesomorphic or an ecto-mesomorphic type. The somatotype score for boxers after one year was 2.6: 4.1: 3.0. Somatotype transformation can also occur for categories within the same zone. In the component composition of body mass for both boxers and fencers, the mesomorphic component is dominant, and the prevailing or dominant somatotype for athletes of both specializations is the ecto-mesomorphic type.

It is clear even to a layperson which changes in a person's morphological structure resulting from sports exercises are beneficial and which are undesirable. The latter include various irreversible or difficult-to-reverse alterations in the musculoskeletal system, particularly changes in the spine in the frontal and sagittal planes. In addition to studying the dynamics of body composition in boxers, we also assessed the posture of qualified boxers studying at the Uzbek State Institute of Physical Culture.

Table 4. Cardiorespiratory system parameters of boxers before and after physical exertion

Specialization	Endo-meso-morph		Ecto-mesomorph		Meso-ectomorph		Endo-ectomorph		Meso-endo-morph		Ecto-endo-morph		Total no. of sub-jects
	n	%	n	%	n	%	n	%	n	%	n	%	48
Boxing	4	16.5	15	62	3	12.5	1	4.5	1	4.5	-	-	24
Fencing	2	8	17	71	3	21.5	1	4	-	-	1	4	24

Thus, among the 10 boxers we examined, right-sided scoliosis (curvature of the spine) was identified in 2 boxers, left-sided in one case, and one boxer presented with pronounced kyphosis (stooping) of the upper thoracic spine. A similar pattern was observed in athletes engaged in fencing.

All the data obtained were statistically processed and presented in tables, which also indicate the significance of each indicator. Table 5 presents the cardiorespiratory system parameters of boxers before and after physical exertion.

The data in Table 5 allow for a comparative analysis of the measured parameters. The data obtained made it possible to draw certain conclusions and formulate the following research results:

a) in skilled boxers and fencers, the baseline capabilities of the cardiorespiratory system are sufficiently high, stable, and within the normal range;

b) after intense physical exertion, cardiorespiratory parameters also increase within the normal range and return to their initial values in a relatively short period of time;

c) the degree and index of recovery are highest among skilled boxers, which indicates their endurance and high level of fitness.

Furthermore, it can be assumed that in this sport, the physical demands are more intensive in nature, as this sport involves maximum exertion over short periods of time with a relatively slow recovery of energy expenditure.

Conclusion

The study identified the features of the morphological structure and functional state of athletes specializing in acyclic sports - boxing and fencing. An analysis of anthropometric indicators showed that fencers have higher thigh circumference values compared to boxers, whereas the diameter of the distal part of the humerus is practically at the same level for representatives of both specializations.

A study of somatotypological characteristics using the Heath-Carter method showed that the mesomorphic component is dominant in the body composition of the athletes, reflecting a high level of muscular system development. The most common somatotype among representatives of both sports specializations is the ecto-mesomorphic type. Its frequency is 71% in fencers, compared to 62% in boxers.

Longitudinal observation of somatotypological indicators showed that certain morphological changes occur under the influence of the training process. In boxers, an increase in the mesomorphic component from 3.5 to 4.1 points was noted over a one-year period, which indicates enhanced muscle mass development and an improved level of physical fitness in the athletes. Furthermore, changes in somatotype can occur both between different types and within a single somatotypological zone.

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